Relating Vegetation Aerodynamic Roughness Length to Interferometric SAR Measurements

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Abstract

In atmospheric boundary layer problems over vegetated land surfaces, the fluxes of sensible heat, latent heat and carbon dioxide are determined in terms of vegetation characteristics. These characteristics are often parameterized in climate (GCM) or soil-vegetation-atmosphere transfer (SVAT) models in terms of vegetation distribution, rooting depth, leaf area index, albedo, aerodynamic parameters, etc. The aerodynamic parameters of vegetation are important to determine the vertical gradients of mean wind speed and the conditions for momentum transfer. In modeling the wind profile and drag over a canopy, the height where the wind speed becomes zero is referred as the aerodynamic roughness length of the vegetation. This roughness length is equivalent to the *rms* height variation of the vegetation at the top of the canopy. Once this roughness length is determined for a certain canopy, it does not change with the wind speed, stability or stress. However, the roughness length can change if the canopy structure and density change. in other words, the aerodynamic roughness is just a vegetation parameter and depends on the vegetation type, structure, height, and coverage. The estimation of this parameter over forest landscapes by remote sensing techniques is crucial for quantifying local and regional land surface-atmospheric interactions. In this paper, we investigate the feasibility of estimating this parameter from interferometric SAR (INSAR) measurements. It has been shown that the phase difference calculated from the cross product of two complex images obtained by INSAR is sensitive to surface height which is defined as the distance between the scattering phase center and a reference line. Over vegetated surfaces, the scattering centers are shifted within the canopy and their relative location depends on the vegetation height, density and type, and the radar wavelength. A scattering model based on wave theory has been developed to simulate the INSAR measurements over forest canopies. In this model the vegetation layer is treated as a discrete random medium where the canopy components are represented as three dimensional canonical geometries. The model simulation shows that the cross-correlation phase and amplitude when averaged over an ensemble of pixels are related to the *rms* height of the vegetation or the aerodynamic roughness length. Model simulations performed over realistic canopy parameters obtained from field measurements in boreal forest environment demonstrate the capability of the INSAR measurements for estimating and mapping surface roughness lengths over forests. The procedure for estimating this parameter over boreal forests using the INSAR data is discussed and the possibility of extending the methodology over tropical forests is examined.

This work has been performed at the Jet Propulsion Laboratory, California Institute of Technology under a grant from the National Aeronautics and Space Administration.